



Project No: **530510-TEMPUS-1-2012-RS-TEMPUS-JPCR**

**Project title:**

Assisting humans with special needs: curriculum for  
**HU**man-**TO**ol interaction **Net**work

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**Acronym: HUTON**

**Deliverable 2.2:**

**Restructured Syllabi and Programs for all courses**

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Duration: **36 months**

Lead beneficiary for this deliverable: **BU**

Responsible Person: Prof. **Prof. Aleksandar Veg, BU**

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Dissemination Level		
<b>NL</b>	National level	
<b>IL</b>	International level (including the Commission Service)	√

## Deliverable 2.2: **Restructured Syllabi and Programs for all courses**

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This deliverable is the second consecutive action in the **WP2: Design of new courses and restructuring of existing courses with supporting teaching materials**

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### **Introduction:**

The wider objective of the project "Assisting humans with special needs: Curriculum for **HUMAN-TOOL** interaction Network (HUTON)" is the development of interdisciplinary and multidisciplinary curriculum with the laboratory educational support and the educational training network for the optimized use of technology that improves the quality of life of humans with special needs

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### **The specific objectives in the project are:**

- Development of the **new interdisciplinary and multidisciplinary accredited curriculum (MECHATRONICS FOR REHABILITATION)** leading to the master degree in the domain of technologies for humans with special needs.
  - Setup of the training **network in Republic of Serbia (RS) in the domain of mechatronics, rehabilitation engineering and medicine, and neurorehabilitation** that enables the delivery of the new interdisciplinary and multidisciplinary curriculum.
  - Training of staff for providing on-the-job education and use of appropriate technologies which increases **new employment opportunities**.
  - Training of staff for providing **better medical services** for humans with special needs.
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The project is planned with eight work packages, where the first four are the development activities.

The assumptions in the WP2 are the following: Review of the existing programs in the domain of the project, the development of the new courses and integration of the existing and new courses. It was anticipated the Serbian partners have expertise for specific courses and capabilities for further improvements. The discussions with the EU partners led to the conclusions that some courses from Slovenian programs could be integrated into the new curriculum.

The WP2 initial activity was the review of existing courses which could be deployed in the new syllabus, but with the emphasis on the parallel development of new courses. The success of the works in the WP 2 is that the review led to the selection of courses that will form the core and set of elective courses.

The focus was on the courses which encircle practical knowledge and applicable skills. The specific action, harmonized with the activities in the WP 3, was to maximize the hands on approach and optimize the use of the instrumentation and equipment that will be purchased. It has been decided that the interdisciplinary approach could be successfully achieved exclusively with the expert team of the HUTON consortium

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The activities were dedicated to the review of the existing courses held either in Serbia or EU partners. Commitments within WP2 were delegated to Serbian partners, where should cover most of the new courses.

Specifically the following roles were delegated:

The decision was reached that the EU partners must be integrated, and that this would be made possible with the timed circulation of all relevant information and plans. This decision was reached at the meeting in Ljubljana, March, 12. 2013.

The main role of UP in WP2 would be in translation of accumulated know-how in design of the new educational methods and teaching skills. The specific know-how comes from the most recent TEMPUS grant in the domain of harmonization of the curricula in Biomedical engineering in Europe.

The main role of UL in WP2 would be assistance in the development of the curricula in Mechatronics and Neurorehabilitation that will be coordinated by the UB and UNS. The group in Ljubljana will also give a consultancy related to the development of the Laboratory work and appropriate teaching material.

The main role of UG in WP2 would be in the domain of the robotics and movement rehabilitation and the development of related courses. More specifically, curricula in Mechatronics and neurorehabilitation that are coordinated by UB and UNP.

## **A Brief review of HUTON Restructured Syllabi and Programs for all courses**

### **Core courses**

1. CONTROL OF MOVEMENTS IN HUMANS, PROF. DEJANPOPOVIC
2. MECHATRONICS FOR HUMAN MOVEMENTS, PROF. ALEKSANDAR VEG
3. HUMAN MOVEMENTS ASSESSMENT, ASS. PROF. LANA  
POPOVICMANESKI
4. DISABILITY ASSESSMENT METHODS AND TREATMENTS, PROF.  
LJUBICAKONSTANTINOVIC

### **M) Electives(engineering background 2 courses, life-sciences background 1 course)**

- M.1 EXTERNAL CONTROL OF BIOLOGICAL ACTUATORS, PROF. NIKOLA  
JORGOVANOVIC
- M.2 MECHANICS OF ROBOTS, PROF.  
BRANISLAVBOROVAC,
- DOC. MIRKORAKOVIC
- M.3 CONTROL FOR MAN-MACHINE SYSTEMS, ASS. PROF.  
TOMISLAVSEKARA
- M.4 PNEUMATIC AND HYDRAULIC ACTUATORS, PROF.  
LJUBOMIRMILADINOVIC
- M.5 ELECTRICAL AND MAGNETIC ACTUATORS, PROF. STEVANSTANKOVSKI
- M6. SENSORS FOR MECHATRONIC SYSTEMS, ASS. PROF.  
TOMISLAVSEKARA
- M7.SIGNALS AND SYSTEMS IN REHABILITATION, ASS. PROF. LANA POPOVICMANESKI

**R) Electives**(engineering background 1 course, life-sciences background 2 courses)

R.1 STATISTICS FOR REHABILITATION RESEARCH,	LECTURER MISSING
R.2 ROBOTICS FOR REHABILITATION,	PROF. DEJANPOPOVIC
R.3 RESEARCH METHODS IN REHABILITATION AND BIOETHICS, LJUBICA KONSTANTINOVIC	PROF.

## CORE COURSES

### CONTROL OF MOVEMENTS IN HUMANS,

PROF. DEJANPOPOVIC

1. Natural Control of Movement Organization. Hierarchical and parallel organization of the motor systems; Neuronal pathways. Mechanisms of muscle contraction in humans. Sensory systems in humans;
2. Mechanisms for postural control. Sensors for control of posture. Central neural mechanisms for control of posture;
3. Mechanisms for control of walking. Bipedal walking. Central pattern generator. The role of peripheral input in generation of normal walking patterns. Biomechanics of bipedal walking;
4. Mechanisms for control of goal-directed movement. Motor planning. Visual guidance in goal-directed movement. Precision of positioning of the hand. Redundancy and synergies. The muscle patterns underlying movement; and
5. Pathology of sensory-motor systems and methods of assessment of Disability. Pathology of sensory-motor systems; Cerebro-vascular accident (Stroke). Spinal cord injuries. Injury of the neuron. The Amputation. Assessment methods of sensory-motor disorders; Clinical scales and quantified measures of the sensory-motor systems.

## **MECHATRONICS FOR HUMAN MOVEMENTS, FOR ALL STUDENTS PROF. ALEKSANDAR VEG**

1. Description of smart machines and devices
  - a. Examples of mechatronic systems
  - b. Chronicle of inventions in machine science, mechanisms, electronics, mechatronics and bionics
  - c. Chronicle of sensing device inventions
2. Targets of mechatronic engineering
  - a. 3D solid modeling
  - b. Mechanical platforms
  - c. Motion generation
  - d. Sensing and controlling
  - e. Mechatronic composition
3. Sensing in mechatronics
  - a. Sensing of ambient parameters
  - b. Sensing of position and motion
  - c. Pattern recognition
  - d. Other sensings
4. Synthetic intelligence
  - a. Processors
  - b. Microcontrollers
  - c. PLCs
5. Drives in mechatronics
  - a. Electric motors and gear boxes
  - b. Pneumatics
  - c. Hydraulics

*for students with engineering background*

1. Applied measurements in mechatronics
  - a. Force, torque
  - b. Displacement, velocity, acceleration
2. Basic design of mechatronic systems
  - a. Design process fundamentals
  - b. Examples
3. Components selection
  - a. Functional requests
  - b. Performance analysis
  - c. Parts arrangement
4. Prototyping principles
  - a. Rapid prototyping
  - b. Functional substitutes
  - c. Criteria for upgrades
5. System integration
  - a. Mechanical substructure
  - b. Adapters and drives
  - c. System brain and sensors
  - d. Programming for the best performance
6. Operational verification
  - a. Program definition
  - b. Basic tests
  - c. System functionality
  - d. Modifications definition

*for students with life sciences background*

1. Applied measurements on humans (limbs...)
  - a. Force, torque
  - b. Displacement, velocity, acceleration
2. Mechanisms and motions in human body
  - a. Arms
  - b. Legs
  - c. Joints
3. Modeling of human motion
  - a. Motion detection and parametric definition
  - b. 3D simulation
4. Control by local smart units
5. Human actuators and substitutes (muscles)
  - a. extensors
  - b. flexors

1. Introduction

- Signals in rehabilitation - electrophysiology and movements
- Measurements instruments in rehabilitation

2. Metrology

- Measurement instruments
- Characteristics of measured signals - deterministic and stochastic signals
- Probability theory
- Measurement uncertainty

3. Bio electrodes

- Characteristics
- Materials
- Models
- Types (reusable, surface, implantable,...)
- Preparing of the skin

4. Sensors (for engineers - functioning principles; for others - application)

- Displacement, position, velocity, acceleration
- Force, pressure
- Temperature

5. a) Acquisition (for engineers)

- Basic analog circuits
- Signal amplifiers
- Filters
- A/D conversion
- Digital circuits



- Power sources

b) Acquisition (for others)

- Instrumentation amplifiers (informative)
- Spectral analysis (basics)
- Filters (application)
- A/D conversion (informative)
- Power sources (informative)

6. Acquisition devices for ECG signals

7. Acquisition devices for EMG and EMNG signals

8. Acquisition devices for EEG signals

9. Acquisition devices for movement signals

10. Signal processing I

- electrophysiological signals
- kinematic signals
- dynamic signals

11. Signal processing II

- Statistical methods
- Wavelets
- Neural networks
- Fractals

12. Safety during measurements

- Grounding
- Devices handling

13. Protocols for clinical studies

*for all students*

1. General Understanding and Use of Microcomputer
  - Basic Structure
  - Characteristics
2. Basic Components of Microcomputers
  - Processor and Microcontroller
  - Memory Types: RAM, ROM, FLASH
  - Buses
  -
3. Microcomputer Peripherals
  - Interrupt Controller
  - Timer and Counter
  - A/D and D/A Converters
  - Communication Controllers
4. Microcomputer Communication
  - RS232
  - RS485
  - USB
  - Bluetooth
  - ETHERNET
  - WiFi
5. Microcomputer Medical Devices
  - Electrical Stimulator
  - Data Acquisition Devices (ECG, EMG, EEG)

# **ELECTIVES (engineering background 2 courses, life-sciences background 1 course)**

## **M1. EXTERNAL CONTROL OF BIOLOGICAL ACTUATORS, PROF. NIKOLA JORGOVANOVIC**

*for all students*

1. Neural and muscular systems for control of movement
  - Activation and inhibition of neural cells
  - Neural networks in the spinal cord and brain
  - Central pattern generator
2. Pathology of Sensory-Motor Systems and Assessment of Disability
  - Pathologies of central nervous system and their consequences on peripheral systems (loss of motor and sensory function)
3. Electrical Stimulation
  - a. Basic Architecture of the Electrical Stimulator
  - b. Pulse Type
  - c. Stimulation Parameters
4. Electrode for Electrical Stimulation
  - a. Electrode model
  - b. Electrode impedance
  - c. Electrode type and dimension
5. Magnetic stimulator
  - a. Stimulation Patterns
  - b. Placement and types of magnetic coils
6. Implantable systems
  - a. Stimulation patterns

- b. Electrodes design and placement
  - c. Stimulation of cortical structures
  - d. Recordings from cortical structures
- 7. Control of electrical and magnetic stimulation systems
  - a. Model based control
  - b. Nonanalytical (finite state) control
- 8. Electrical Safety
  - a. Physiological Effects of Electricity
  - b. Macroshock and Microshock Hazards
  - c. Electrical Safety Codes and Standards
  - d. Basic Approaches to Protection against Shock
  - e. Protection: Equipment and Procedure Design

1. Description of control systems

- Physical Quantities
- What is Feedback
- What is Control
- Open loop and Closed loop systems
- Sensors and Actuators

2. Process models and control structures

- Transfer function and state space models
- Basic controller structures
- Complex controllers

3. Characteristics of control systems

- Time domain analysis
- Frequency domain analysis
- Control systems stability

4. Identification of processes

- Open loop process identification (time domain and frequency domain)
- Closed loop process identification (time domain and frequency domain)

5. Process characterization

- Relay based methods
- Phase locked-loop (PLL) based methods

6. PI/PID control

- Basic control function
- Simple controllers for complex systems
- Robust and optimal tuning PI/PID controllers

- Feed-forward design
- Integrator windup
- Implementation

#### 7. Performance and robustness of control systems

- Performance specifications
- Robustness specifications
- Design for robust performance

#### 8. Complex controls system design

- Smith predictor
- Modified smith predictor
- Observer of disturbance
- Implementation

#### 9. Multivariable feedback control

- Transfer function of MIMO systems
- Control of multivariable plants
- Decentralized feedback control
- Simple controllers for MIMO systems

1. Description of sensors

- Physical Quantities
- Electrical signals
- Energy conversion
- Sensor Systems
- Wheatstone bridge

2. Characteristics of sensors

- Passive and active sensors
- Static characteristics
- Dynamic characteristics

3. Displacement sensors

- Potentiometers
- Resistive strain gauge
- Capacitive and inductive transducer (Measurement of level)
- Absolute and incremental encoders

4. Speed sensors

- Translational speed sensor
- Rotational speed sensor
- Tachometer and tachogenerator

5. Measurement of force and torque

- Strain gauge
- Piezoelectric effect
- Accelerometers and servo accelerometers

6. Accelerometer sensors

- Classic accelerometers
- Servo accelerometers

#### 7. Pressure sensors

- Electromagnetic sensor
- Capacitive and inductive sensor
- Optoelectronic sensor
- Potentiometers and piezoelectric sensor

#### 8. Flow sensors

- Venturi tube
- Ultrasonic flow sensor
- Induction flow sensor

#### 9. Temperature sensors

- Expansion temperature sensor
- Resistive and Semiconductor temperature sensor
- Thermocouple temperature sensors

#### 10. Tactile sensors and vision sensors

- Resistive, Capacitive, Piezoelectric, Optoelectronic and Electromagnetic tactile sensors
- Ultrasonic and Optoelectronic vision sensors



## **M7. SIGNALS AND SYSTEMS IN REHABILITATION, ASS. PROF. LANA POPOVICMANESKI**

### 1. Electrophysiology

- Nerve cell
- Nervous system
- Membrane potential
- Action potential generation and propagation

### 2. Characteristics of measured signals

- Time domain
- Spectral domain
- Deterministic and stochastic signals

### 3. Muscle signals

- Musculoskeletal system
- EMG
- EMNG
- Reflexes
- Action potential characteristics

### 4. Modelling

- Nervous system
- Musculoskeletal system
- Representation of movement

### 5. Cortical signals

- EEG
- Action potential characteristics
- MEG

## 6. ECG

- Cardio-vascular system
- Action potential characteristics

## 7. Pathologies leading to sensory-motor impairment

- Stroke, spinal cord injury, Parkinson disease, etc
- Invalidity scales - Fugl-Meyer, Ashworth, ASIA, UPDRS, etc
- Quality of life

## 8. Stimulation

- Electrical stimulation
- Magnetic stimulation
- Evoked potentials
- Applications

## 9. Rehabilitation

- Conventional approaches
- Intensive exercise
- Neurofeedback
- Robotic systems
- Electrical and magnetic stimulation
- Implantable systems

*engineering affiliation students*

1. ARM Microcontroller
  - Architecture
  - Control and Status Registers
  - Memory and Memory Access
  - Peripherals
2. C language for ARM Microcontroller
  - Programming Basics
  - Practical Solutions
3. Data acquisition Systems in Detail
  - Analogue Signal Processing
  - A/D Conversion: Sampling, Aliasing, Type of A/D Converters
  - Optocouplers and Isolation Amplifiers
  - Protection Circuits
4. Digital signal processing
  - Filters
  - FFT

*medical affiliation students*

1. User Interfaces
  - Basic
  - Textual User Interface
  - Graphical User Interface

## 2. Operating Systems

- Windows
- Android

## 3. Computer Peripherals

- Printers
- Scanners
- Cameras

## **Electives(engineering background 1 course, life-sciences background 2 courses)**

### **R2. ROBOTICS FOR REHABILITATION,**

**PROF. DEJANPOPOVIC**

#### *for all students*

1. Introduction to medical robotics
2. Artificial limbs (upper extremities, lower extremities)
3. Interfaces for artificial limbs
4. Robots for assistance of the standing and walking
5. Robots for assistance of upper extremities
6. Principles of application of assistive robots

#### *for students with engineering background*

- Hardware and actuators of artificial arms/hands
- Hardware for artificial legs (foot, transtibial and transradial prostheses)
- Sensors for artificial limbs
- Control methods for artificial limbs based on analytical models and soft computing
- Design considerations for the assistive robots

#### *for students with life sciences background*

- Selection of the appropriate robotics based on pathologies
- Inclusion and exclusion criteria for patients
- Clinical application of robots in rehabilitation
- Assessment methods based on the robotic systems
- Robots for the home use
- Considerations for the telemedical use of assistive robots

### **R3. RESEARCH METHODS IN REHABILITATION AND BIOETHICS,**

**PROF. LJUBICA KONSTANTINOVIC**

1. Rehabilitation process
  - Models of rehabilitation
  - Components of rehabilitation
  - Functional evaluation and outcome measurement
  - Psychometric properties of functional tests
2. Types of research studies
  - Observational studies
  - Descriptive studies
  - Analytical studies
  - Case control studies
  - Analytic surveys
  - Cohort studies
  - Experimental studies
  - Quazi-experimental studies
  - Alternative design studies in rehabilitation
3. Structure of research studies
  - Preliminary phase of clinical studies
  - Formulation of research question
  - Development of clinical study
4. Methods and phases of clinical studies
  - Safety and feasibility studies
  - Preliminary efficacy studies
  - Classical experimental design

5. Specific issues of interventional research
  - Selection of patients
  - Randomisation and blinding
  - Parameters and outcome measurement
6. Research design and plan
  - Sampling
  - Measurement and scaling testing
  - Data collection method
  - Testing of hypothesis
  - Analyzing and interpretation
7. Therapeutic interventions
  - Description of intervention
  - Polymodal interventions
  - Standardization of therapeutic interventions
8. Biostatistics in rehabilitation
  - Approach to statistical analyses
  - Statistical methods
9. Phases and styles of the reportin
  - Structure of scientific reports
  - Types of scientific reports
  - Specific characteristics of elements of scientific reports
10. Ethical issues in clinical research in rehabilitation
  - Historical background
  - Concepts of medical ethics
  - Principles of fairness